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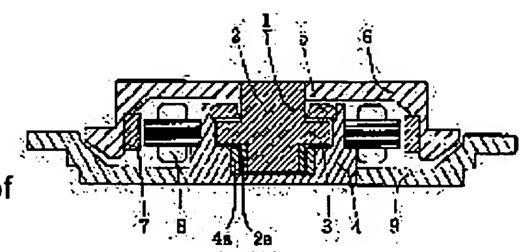
(54) LIQUID DYNAMIC PRESSURE BEARING AND SPINDLE MOTOR

(57)Abstract:

PROBLEM TO BE SOLVED: To substantially stabilize bearing rigidity over a wide temperature range with a simple structure, in a liquid dynamic pressure bearing having at least a shaft member, a sleeve member receiving the shaft member, and lubricating oil charged in minute clearances including bearing clearance, and a spindle motor having the same.



SOLUTION: A cylindrical member 2a made of material of large linear expansion coefficient is externally fitted to a lower side of a flanged shaft member 1 as a shaft member. A radial dynamic pressure generation groove is formed on an outer peripheral surface of the cylindrical member 2a. A cylindrical member 4a made of material of large linear expansion coefficient is internally fitted to a small diameter cylindrical part on a lower side of a stepped cylindrical sleeve member 4. With such a setup, range of automatic adjustment is increased in respect to clearance of the bearings according to temperature variation. It is thus possible to compensate variation of bearing rigidity due to viscous coefficient of lubricating oil by the variation of the bearing

rigidity due to bearing clearance for a wide temperature range.

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* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to a means to hold bearing rigidity almost uniformly over a large temperature requirement especially, about the spindle motor possessing a liquid hydrodynamic bearing and this.
[0002]
[Description of the Prior Art] A liquid hydrodynamic bearing consists of lubricating oils with which the minute clearance containing the bearing clearance formed at least between a shaft member, the sleeve member which receives this shaft member, and these two members was filled up. A rise of temperature reduces the bearing rigidity of a liquid hydrodynamic bearing. This is because the coefficient of viscosity of a lubricating oil will fall if temperature rises. For this reason, some means to hold the bearing rigidity of a liquid hydrodynamic bearing over a large temperature requirement as uniformly as possible have been proposed thru/or carried out.
[0003] In drawing 7 which shows the conventional liquid hydrodynamic bearing, the shaft member which is a shaft member is the shaft member 1 with a flange which consists of a disk member 3 for thrust dynamic pressure pressed fit in the cylinder member 2 and this cylinder member 2. the body of the minor diameter where the sleeve member into which this shaft member 1 with a flange fits free [rotation] has a bottom -- the lower berth -- and the body of the major diameter which has the opening edge which carried out opening to atmospheric air is the cylindrical sleeve member 4 with a stage formed in the upper case, respectively. The opening edge of the cylindrical sleeve member 4 is closed by the annular presser-foot member 5. The radial dynamic pressure generating slot G1 is formed in the peripheral face of the cylinder member 2 bottom. The thrust dynamic pressure generating slot G2 is formed in the top face and inferior surface of tongue of the disk member 3 for thrust dynamic pressure, respectively.
[0004] Between the shaft member 1 with a flange, the cylindrical sleeve member 4, and the annular presser-foot member 5, the minute clearances R1, R2, R3, R4, and R5 are formed. The minute clearances R1, R2, R3, and R4 are bearing clearances, and the minute clearance R5 functions as a lubrication oil sump. All these minute clearances are filled up with the lubricating oil F. Although these minute clearances are based also on the size of a fluid hydrodynamic bearing, a rotational frequency, and the coefficient of viscosity of a lubricating oil, they are several micrometers to about several 100 micrometers.
[0005] Moreover, the cylindrical sleeve member 4 is produced with stainless steel, and the shaft member 1 with a flange is manufactured with the ingredient which has a bigger coefficient of linear expansion than stainless steel, for example, brass. Thus, it is made for spacing of a bearing clearance to become narrow in connection with the temperature rise by selecting the ingredient of a bearing member in consideration of coefficient of linear expansion. Spacing of a bearing clearance is automatically adjusted with temperature. According to the effectiveness of automatic accommodation of spacing of this bearing clearance, bearing rigidity is also adjusted automatically. That is, in a pyrosphere, as for the bearing

clearance formed between the shaft member and the sleeve member, the spacing becomes narrow, and bearing rigidity increases. A ** grade compensates a reduction of bearing rigidity according [the increment in this bearing rigidity] to the coefficient-of-viscosity fall of a lubricating oil.
[0006] When the conventional liquid hydrodynamic bearing shown in drawing 7 selects the cylindrical sleeve member 4 and the shaft member 1 with a flange so that the latter coefficient of linear expansion may become larger than that former, spacing of a bearing clearance is automatically adjusted with temperature, and a ** grade controls the fall of bearing rigidity by the pyrosphere. however -- general -- the difference of the coefficient of linear expansion between metallic materials -- at most -- since it is about 2-5x10-5/degree C, the width of face which can adjust spacing of a bearing clearance automatically with temperature is small, and, for this reason, it is very difficult in the conventional liquid hydrodynamic bearing actually to hold bearing rigidity to about 1 law over a large temperature requirement. Even if realizable, there is a problem that the width of face of selection of the ingredient which constitutes bearing is very narrow, and the liquid hydrodynamic bearing suitable for various applications cannot be realized by such approach.
[0007] It is the liquid hydrodynamic bearing which consisted of lubricating oils with which the minute clearance which includes the radial bearing clearance formed between the metal shaft member, the metal sleeve member, and these two member in a U.S. Pat. No. 5,524,985 official report was filled up, and the liquid hydrodynamic bearing which lined synthetic resin to the inner skin of said metal sleeve which forms a radial bearing clearance is indicated. That is, using the coefficient of linear expansion of synthetic resin being larger than a metal, by the pyrosphere, this liquid hydrodynamic bearing narrows spacing of a radial bearing clearance, and maintains bearing rigidity almost uniformly. However, this liquid hydrodynamic bearing also has the problem that the width of face of selection of the ingredient which constitutes bearing is very narrow, and the liquid hydrodynamic bearing suitable for various applications cannot be realized by such approach.
[0008] On the other hand, the liquid hydrodynamic bearing indicated by JP,10-112955,A consists of a shaft member, a sleeve member which receives this shaft member, and a lubricating oil at least. And said sleeve member forms that inner skin with the porous material like a metal particle sintering object, and makes it filled up with a resin ingredient with a bigger coefficient of linear expansion than that sintering object in the micropore of a majority of this metal particle sintering object, and further, in order to prevent exsorption of a lubricating oil, it comes to close all front faces other than that inner skin with water glass. Moreover, mist and a big ingredient are adopted as the shaft member for coefficient of linear expansion from the coefficient of linear expansion of a sleeve member.
[0009] the following shafts [since it has a minute gap in the micropore of the inner skin of a sleeve in this liquid hydrodynamic bearing although that coefficient of viscosity becomes high when a lubricating oil is below ordinary temperature, through that micropore, a lubricating oil leaks from a part with a high pressure to a low part, and prevents past / of a pressure / a riser /, and] the time of ordinary temperature -- disadvantage increase is mitigated. So to speak, the minute gap of the micropore of a large number formed in the inner skin of a sleeve is automatically adjusted with temperature, making it function as a kind of oilless bearing. On the other hand, since the minute gap of the micropore of the inner skin of a sleeve contracts or blockades although the coefficient of viscosity falls if the temperature of a lubricating oil rises, the pressure of a lubricating oil approaches the pressure decided with parameters, such as coefficient of viscosity of the lubricating oil in the temperature, and spacing of a bearing clearance, or turns into the pressure itself, and the fall of bearing rigidity by the temperature rise is prevented.
[0010] Using the thermal expansion of the resin ingredient with which the sleeve member which formed the inner skin with the porous material like a metal particle sintering object was filled up, the liquid hydrodynamic bearing indicated by JP,10-112955,A tends to adjust the minute gap of the micropore of a porous material automatically with temperature, and tends to hold bearing rigidity over a large temperature requirement as uniformly as possible. However, it is actually difficult to realize the liquid hydrodynamic bearing which fixed bearing rigidity mostly over the large temperature requirement also by this approach. Moreover, since a special sleeve member is used, the design and manufacture have the

problem that processing cost is high rather than are easy.
[0011] By selecting a lubricating oil appropriately, a certain extent can ease the temperature dependence of bearing rigidity of a liquid hydrodynamic bearing. By the way, since change of coefficient of viscosity is small over the temperature requirement where the lubricating oil with low coefficient of viscosity is large, the purpose that a certain extent eases the temperature dependence of bearing rigidity of a liquid hydrodynamic bearing is suited. However, such a lubricating oil has the problem of being hard to make. On the other hand, although it is easy to make the lubricating oil with high coefficient of viscosity, coefficient of viscosity changes a lot over a large temperature requirement. Therefore, becomes large too much and bearing rigidity tends to become small too much in a pyrosphere in a low-temperature region.
[0012]
[Problem(s) to be Solved by the Invention] The sleeve member from which the technical problem which this invention tends to solve receives a shaft member and this shaft member, In the spindle motor possessing the liquid hydrodynamic bearing and this which consisted of lubricating oils with which the minute clearance containing the bearing clearance formed between these two members was filled up with an easy configuration It is migrating to a large temperature requirement, compensating the change of bearing rigidity by the coefficient of viscosity of a lubricating oil with the change of bearing rigidity by the bearing clearance, and making bearing rigidity regularity mostly.
[0013]
[Means for Solving the Problem] In the liquid hydrodynamic bearing constituted including the lubricating oil with which the minute clearance which contains the bearing clearance formed between a shaft member, a sleeve member, and these two members in order to solve the above-mentioned technical problem was filled up The outside section of said shaft member is formed with a bigger ingredient than the coefficient of linear expansion of the ingredient of the inside section, and the inside section of said sleeve member is formed with the ingredient which has a bigger coefficient of linear expansion than the coefficient of linear expansion of the ingredient of the outside section, and spacing of a bearing clearance was automatically adjusted with temperature.
[0014] Moreover, it sets to the liquid hydrodynamic bearing which consisted of lubricating oils with which the minute clearance containing the bearing clearance formed between a shaft member with a flange, a cylindrical sleeve member, annular presser-foot members, and these members was filled up. The outside section of said shaft member is formed with a bigger ingredient than the coefficient of linear expansion of the ingredient of the inside section. The inside section of said sleeve member is formed with a bigger ingredient than the coefficient of linear expansion of the ingredient of the outside section, the inside section of said annular presser-foot member is further formed with the ingredient which has a bigger coefficient of linear expansion than the coefficient of linear expansion of the outside section, and spacing of a bearing clearance was automatically adjusted with temperature.
[0015] Furthermore, the liquid hydrodynamic bearing was constituted as a metal sleeve member which said shaft member was used as the metal shaft member by which outer fitting of the outside section was carried out to the inside section, and it was formed in it, and inner fitting of the inside section was carried out to the outside section in said sleeve member, and was formed.
[0016]
[Embodiment of the Invention] The liquid hydrodynamic bearing which contains the shaft member 1 with a flange, and the cylindrical-with stage sleeve member 4 as one example of the spindle motor concerning this invention is shown in drawing 1 , It is made the same axle at the edge of the shaft member 1 with a flange. It is attached in the peripheral face of the Rota magnet 7 attached in the inner skin of the skirt-board section of the cup-like hub 6 which fixes and holds body of revolution, such as a hard disk, and this cup-like hub 6, and the cylindrical-with stage sleeve member 4, and has two incomes with the Rota magnet 7. It consists of a stator coil 8 made to generate turning effort and a motor substrate 9.
[0017] The 1st example of the liquid hydrodynamic bearing adopted as the spindle motor of drawing 1 contains the shaft member 1 with a flange, and the cylindrical sleeve member 4, as a minute clearance is

exaggerated and shown in drawing 3 which is the fragmentary sectional view filled up with drawing 2 and the lubricating oil which are a sectional view except a lubricating oil. The shaft member 1 with a flange is a cross-section cross member which consisted of a disk member 3 for thrust dynamic pressure formed in the cylinder member 2, this cylinder member 2, and one, and cylinder member 2a by which outer fitting was carried out to the cylinder member 2 bottom. Here, the shaft external surface section is cylinder member 2a, and the shaft inside section is the remaining part of the shaft member 1 with a flange except cylinder member 2a. The shaft external surface section consists of ingredients which have a bigger coefficient of linear expansion than the coefficient of linear expansion of the ingredient of the shaft external surface section.

[0018] the body of the minor diameter where the cylindrical sleeve member 4 has a bottom in the lower berth -- and it is the member by which the body of the major diameter which has the opening edge which carried out opening to atmospheric air was formed in the upper case, respectively, and inner fitting of the cylinder member 4a was further carried out to the body of the minor diameter. Here, the sleeve inside section is cylinder member 4a, and the sleeve external surface section is the remaining part of the cylindrical sleeve member 4 except cylinder member 4a. The sleeve inside section consists of ingredients which have a bigger coefficient of linear expansion than the coefficient of linear expansion of the ingredient of the sleeve external surface section.

[0019] The annular step is formed in the opening edge of the cylindrical sleeve member 4, the annular presser-foot member 5 is pressed fit in this annular step, and the opening edge of the cylindrical sleeve member 4 is closed by this. The radial dynamic pressure generating slot G1 is for example, a partial slot or a herringbone slot, and is formed in the peripheral face of cylinder member 2a by which outer fitting was carried out to the cylinder member 2 bottom. Moreover, the thrust dynamic pressure generating slot G2 is a herringbone slot shown in drawing 6 , and is formed in the top face and inferior surface of tongue of the disk member 3 for thrust dynamic pressure, respectively. The radial dynamic pressure generating slot G1 may be formed in the peripheral face of the disk member 3 for thrust dynamic pressure instead of cylinder member 2a.

[0020] The minute clearances R1, R2, R3, R4, and R5 formed between the shaft member 1 with a flange, the cylindrical sleeve member 4, and the annular presser-foot member 5 are filled up with lubrication oil F. In the 1st example, the bearing clearance for radials is the minute clearance R4, and the bearing clearances for thrust dynamic pressure are the minute clearances R1 and R2. Although the annular minute taper slot S which the cross section opened to atmospheric air is formed between the peripheral face of the cylinder member 2 top, and the inner skin of the annular presser-foot member 5, this is KYAPIRARISHI-RU using an operation of capillarity and surface tension of a lubricating oil F.

[0021] the member which forms the shaft external surface section which faces the bearing clearance R4 for radial dynamic pressure in the 1st example -- among those, the former of the member from which, as for the member which constitutes the surface part, the former constitutes the member which forms the sleeve inside section which is an ingredient with a larger coefficient of linear expansion than the latter, and faces the bearing clearance R4 for radial dynamic pressure, and its outside section is an ingredient with a larger coefficient of linear expansion than the latter.

[0022] For this reason, although the shaft member 1 with a flange, the cylindrical-with stage sleeve member 4, and the annular presser-foot member 5 will expand and spacing of the minute clearances R1, R2, R3, R4, and R5 will become narrow if temperature rises, how depending on which spacing of the bearing clearance R4 for radial dynamic pressure narrows especially is large. It is because the inside is regulated by the member with a small coefficient of linear expansion in the shaft member 1, and the outside is regulated by the member with a small coefficient of linear expansion in the sleeve member 4, so cylinder member 2a by the side of a shaft with a large coefficient of linear expansion and cylinder member 4a by the side of a sleeve expand more mostly to the inside of a bearing clearance. On the contrary, although the shaft member 1 with a flange, the cylindrical-with stage sleeve member 4, and the annular presser-foot member 5 will contract and spacing of the minute clearances R1, R2, R3, R4, and R5 will become large if temperature falls, how depending on which spacing of the bearing clearance R4 for radial dynamic pressure spreads especially is large.

[0023] Thus, spacing of a bearing clearance can be changed now conventionally a lot than equipment, and the width of face which can be automatically adjusted with temperature in the liquid hydrodynamic bearing concerning this invention spread. Therefore, bearing rigidity can be more dynamically adjusted automatically using the effectiveness of automatic accommodation of spacing of the bearing clearance by this temperature. That is, in a pyrosphere, as for the bearing clearance for radial dynamic pressure formed between the shaft member and the sleeve member, the spacing becomes narrow, and bearing rigidity increases. The increment in this bearing rigidity is magnitude which compensates the reduction of bearing rigidity by the coefficient-of-viscosity fall of a lubricating oil, therefore predetermined bearing rigidity is held in a pyrosphere. On the other hand, in a low-temperature region, as for the bearing clearance for radial dynamic pressure formed between the shaft member and the sleeve member, the spacing becomes large, and bearing rigidity falls. The fall of this bearing rigidity is magnitude which compensates the increment in bearing rigidity by coefficient-of-viscosity rise of a lubricating oil, therefore predetermined bearing rigidity is held also in a low-temperature region. Namely, it migrates to a large temperature requirement and the change of bearing rigidity by the coefficient of viscosity of a lubricating oil can be compensated now with the change of bearing rigidity by the bearing clearance.
[0024] Next, as the 2nd example of a liquid hydrodynamic bearing exaggerates and shows a minute clearance to drawing 5 which is the fragmentary sectional view filled up with drawing 4 and the lubricating oil which are a sectional view except a lubricating oil, the basic configuration is the same as the 1st example. A difference is in the configuration which realizes automatic spacing accommodation of the bearing clearance by temperature. That is, the shaft member 1 with a flange is a cross-section cross member which consisted of disk member 3a for thrust dynamic pressure by which was formed in the cylinder member 2, this cylinder member 2, and another object, and outer fitting was carried out to the pars intermedia of the cylinder member 2, and cylinder member 2a by which outer fitting was carried out to the cylinder member 2 bottom. Disk member 3a for thrust dynamic pressure and cylinder member 2a are formed in one. Here, the shaft external surface sections are cylinder member 2a and disk member 3for thrust dynamic pressure a, and the shaft inside section is the remaining part of the shaft member 1 with a flange except cylinder member 2a and disk member 3a for thrust dynamic pressure. The shaft external surface section consists of ingredients which have a bigger coefficient of linear expansion than the coefficient of linear expansion of the ingredient of the shaft external surface section.
[0025] the body of the minor diameter where the cylindrical sleeve member 4 of a liquid hydrodynamic bearing has a bottom in the lower berth -- and it is the member by which the body of the major diameter which has the opening edge which carried out opening to atmospheric air was formed in the upper case, respectively, and inner fitting of the cylinder member 4with stage a was further carried out to the body of the minor diameter, the body of a major diameter, and the step in the meantime. Here, the sleeve inside section is cylinder member 4a, and the sleeve external surface section is the remaining part of the cylindrical sleeve member 4 except cylinder member 4a. The sleeve inside section consists of ingredients which have a bigger coefficient of linear expansion than the coefficient of linear expansion of the ingredient of the sleeve external surface section.
[0026] The annular step is formed in the opening edge of the cylindrical sleeve member 4, the annular presser-foot member 5 is pressed fit in this annular step, and the opening edge of the cylindrical sleeve member 4 is closed by this. Inner fitting of the disk member 5a is carried out to the inside the annular presser-foot member 5 faces the minute clearance R1. Here, the coefficient of linear expansion of this disk member 5a is larger than the coefficient of linear expansion of the remaining part of the annular presser-foot member 5 except disk member 5a.
[0027] the member which forms the shaft external surface section which faces the bearing clearance R4 for radial dynamic pressure in the 2nd example -- among those, the former of the member from which, as for the member which constitutes the surface part, the former constitutes the member which forms the sleeve inside section which is an ingredient with a larger coefficient of linear expansion than the latter, and faces the bearing clearance R4 for radial dynamic pressure, and its outside section is an ingredient with a larger coefficient of linear expansion than the latter. Moreover, the member which forms the shaft inside section which faces the bearing clearance R1 for thrust dynamic pressure, and the member which

forms the inside section of an annular presser-foot member are members with a large coefficient of linear expansion as compared with the member which forms each outside section. furthermore, the member which forms the shaft external surface section which faces the bearing clearance R3 for thrust dynamic pressure -- among those, the former of the member from which, as for the member which constitutes the surface part, the former constitutes the member which forms the sleeve inside section which is an ingredient with a larger coefficient of linear expansion than the latter, and faces the bearing clearance R3 for thrust dynamic pressure, and its outside section is an ingredient with a larger coefficient of linear expansion than the latter.

[0028] For this reason, although the shaft member 1 with a flange, the cylindrical-with stage sleeve member 4, and the annular presser-foot member 5 will expand and spacing of the minute clearances R1, R2, R3, R4, and R5 will become narrow if temperature rises, how depending on which spacing of the bearing clearances R1 and R2 for thrust dynamic pressure and the bearing clearance R4 for radial dynamic pressure narrows especially is large. On the contrary, although the shaft member 1 with a flange, the cylindrical-with stage sleeve member 4, and the annular presser-foot member 5 will contract and spacing of the minute clearances R1, R2, R3, R4, and R5 will become large if temperature falls, how depending on which spacing of the bearing clearances R1 and R2 for thrust dynamic pressure and the bearing clearance R4 for radial dynamic pressure spreads especially is large.

[0029] Thus, spacing of a bearing clearance can be changed now conventionally a lot than equipment, and the width of face which can be automatically adjusted with temperature in the liquid hydrodynamic bearing concerning this invention spread. Therefore, bearing rigidity can be more dynamically adjusted automatically using the effectiveness of automatic accommodation of spacing of the bearing clearance by this temperature. That is, in a pyrosphere, as for the bearing clearance formed between the shaft member and the sleeve member, the spacing becomes narrow, and bearing rigidity increases. The increment in this bearing rigidity is magnitude which compensates the reduction of bearing rigidity by the coefficient-of-viscosity fall of a lubricating oil, therefore predetermined bearing rigidity is held in a pyrosphere. On the other hand, in a low-temperature region, as for the bearing clearance formed between the shaft member and the sleeve member, the spacing becomes large, and bearing rigidity falls. The fall of this bearing rigidity is magnitude which compensates the increment in bearing rigidity by coefficient-of-viscosity rise, therefore predetermined bearing rigidity is held also in a low-temperature region. Namely, it migrates to a large temperature requirement and the change of bearing rigidity by the coefficient of viscosity of a lubricating oil can be compensated now with the change of bearing rigidity by the bearing clearance.

[0030] In addition, as an ingredient with a large coefficient of linear expansion, copper system metals, such as phosphor bronze and brass, the aluminum system metal, and the titanium system metal are suitable, and iron system metals, such as stainless steel and pure iron, the molybdenum system metal, and the tungsten system metal are suitable as an ingredient with a small coefficient of linear expansion. In the design of the liquid hydrodynamic bearing concerning this invention, the thing of the optimal combination is chosen out of these ingredients based on a design condition. Moreover, the bearing clearance of being formed so that a clearance may be maintained also in a use maximum temperature is natural.

[0031]

[Effect of the Invention] The liquid hydrodynamic bearing concerning this invention could form the outside section of a shaft member with the bigger ingredient than the coefficient of linear expansion of the ingredient of the inside section, and the inside section of said sleeve member could be formed with the bigger ingredient than the coefficient of linear expansion of the ingredient of the outside section, change width of face by the temperature of spacing of a bearing clearance can be made conventionally larger than equipment now, and the width of face which can be automatically adjusted with temperature spread. Therefore, it migrated to the large temperature requirement, the change of bearing rigidity by the coefficient of viscosity of a lubricating oil can be compensated now with the change of bearing rigidity by the bearing clearance, it became possible to hold bearing rigidity almost uniformly, and stabilization of the bearing engine performance has been realized.

[0032] Moreover, since the configuration was a comparatively easy thing which is easy to manufacture, it was able to suppress the rise of the manufacturing cost of a liquid hydrodynamic bearing. Furthermore, since the automatic accommodation by the temperature of bearing-clearance spacing was attained over the large temperature requirement, the high design of a degree of freedom is attained to the temperature characteristic of a lubricating oil, and the small thin spindle motor could be realized easily.

[Translation done.]

CLAIMS

[Claim(s)]
[Claim 1] In the liquid hydrodynamic bearing constituted including the lubricating oil with which the minute clearance containing the bearing clearance formed between the sleeve member which consists of a shaft member which consists of the inside section and the outside section, and the inside section and the outside section, and these two members was filled up The outside section of said shaft member is formed with a bigger ingredient than the coefficient of linear expansion of the ingredient of the inside section. And the liquid hydrodynamic bearing characterized by forming the inside section of said sleeve member with the ingredient which has a bigger coefficient of linear expansion than the coefficient of linear expansion of the ingredient of the outside section, and adjusting spacing of a bearing clearance automatically with temperature.
[Claim 2] The cylindrical sleeve member which consists of a shaft member with a flange which consists of the inside section and the outside section, and the inside section and the outside section, In the liquid hydrodynamic bearing which consisted of lubricating oils with which the minute clearance containing the bearing clearance formed between the annular presser-foot members which consist of the inside section and the outside section, and these members was filled up The outside section of said shaft member is formed with a bigger ingredient than the coefficient of linear expansion of the ingredient of the inside section. The inside section of said sleeve member is formed with a bigger ingredient than the coefficient of linear expansion of the ingredient of the outside section. Furthermore, the liquid hydrodynamic bearing characterized by forming the inside section of said annular presser-foot member with the ingredient which has a bigger coefficient of linear expansion than the coefficient of linear expansion of the outside section, and adjusting spacing of a bearing clearance automatically with temperature.
[Claim 3] Said sleeve member is claim 1 or the liquid hydrodynamic bearing of 2 which is the metal shaft member in which outer fitting of the outside section was carried out to the inside section, and said shaft member was formed, and is characterized by being the metal sleeve member by which inner fitting of the inside section was carried out to the outside section, and it was formed.
[Claim 4] The spindle motor characterized by using claim 1 or the liquid hydrodynamic bearing of 2 for bearing.

[Translation done.]

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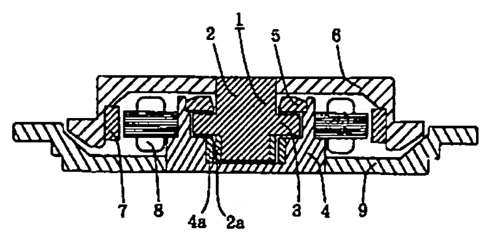
(54)【発明の名称】 液体動圧軸受及びスピンドルモータ

(57)【要約】
【課題】 少なくともシャフト部材と、このシャフト部材を受けるスリーブ部材と、軸受隙間を含む微小隙間に充填された潤滑油とで構成された液体動圧軸受及びこれを具備したスピンドルモータにおいて、簡単な構成で、広い温度範囲にわたって軸受剛性をほぼ一定にすること。
【解決手段】シャフト部材であるフランジ付シャフト部材1の下側には線膨張係数の大きな材料の円筒部材2aを外嵌する。円筒部材2aの外周面にはラジアル動圧発生溝を形成する。段付円筒状スリーブ部材4の下側の小径円筒部には線膨張係数の大きな材料の円筒部材4aを内嵌する。このような構成により、温度変化に対する軸受隙間の間隔の自動的な調節の幅を大きくした。従って、広い温度範囲にわたって、潤滑油の粘性係数による軸受剛性の変化を軸受隙間による軸受剛性の変化で補償できるようにした。



【特許請求の範囲】

【請求項1】内面部と外面部とからなるシャフト部材と、内面部と外面部とからなるスリーブ部材と、これら２つの部材の間に形成された軸受隙間を含む微小隙間に充填された潤滑油とを含んで構成された液体動圧軸受において、前記シャフト部材の外面部を内面部の材料の線膨張係数よりも大きな材料で形成し、且つ前記スリーブ部材の内面部を外面部の材料の線膨張係数よりも大きな線膨張係数を有する材料で形成し、軸受隙間の間隔を温度によって自動的に調節するようにしたことを特徴とする液体動圧軸受。

【請求項2】内面部と外面部とからなるフランジ付シャフト部材と、内面部と外面部とからなる円筒状スリーブ部材と、内面部と外面部とからなる環状押さえ部材と、これらの部材の間に形成された軸受隙間を含む微小隙間に充填された潤滑油とで構成された液体動圧軸受において、前記シャフト部材の外面部を内面部の材料の線膨張係数よりも大きな材料で形成し、前記スリーブ部材の内面部を外面部の材料の線膨張係数よりも大きな材料で形成し、更に前記環状押さえ部材の内面部を外面部の線膨張係数よりも大きな線膨張係数を有する材料で形成し、軸受隙間の間隔を温度によって自動的に調節するようにしたことを特徴とする液体動圧軸受。

【請求項3】前記シャフト部材は外面部が内面部に外嵌されて形成された金属製シャフト部材であり、且つ前記スリーブ部材は内面部が外面部に内嵌されて形成された金属製スリーブ部材であることを特徴とする請求項1又は２の液体動圧軸受。

【請求項4】軸受に請求項1又は２の液体動圧軸受を用いたことを特徴とするスピンドルモータ。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、液体動圧軸受及びこれを具備したスピンドルモータに関し、特に広い温度範囲にわたって軸受剛性をほぼ一定に保持する手段に関する。

【０００２】

【従来の技術】液体動圧軸受は少なくともシャフト部材と、このシャフト部材を受けるスリーブ部材と、これら２つの部材の間に形成された軸受隙間を含む微小隙間に充填された潤滑油とで構成されたものである。液体動圧軸受の軸受剛性は、温度が上昇すると低下する。これは、温度が上昇すると潤滑油の粘性係数が低下するからである。このため、液体動圧軸受の軸受剛性を広い温度範囲にわたって可能な限り一定に保持する手段がいくつか提案ないし実施されてきた。

【０００３】従来の液体動圧軸受を示す図７において、シャフト部材であるシャフト部材は円柱部材２と、この円柱部材２に圧入されたスラスト動圧用円盤部材３とからなるフランジ付シャフト部材１である。このフランジ付シャフト部材１が回転自在に嵌合するスリーブ部材は、底のある小径の円筒部が下段に、且つ大気に開口した開口端を有する大径の円筒部が上段に夫々形成された段付の円筒状スリーブ部材４である。円筒状スリーブ部材４の開口端は環状押さえ部材５によって塞がれている。ラジアル動圧発生溝Ｇ１は円柱部材２の下側の外周面に形成されている。スラスト動圧発生溝Ｇ２はスラスト動圧用円盤部材３の上面と下面に夫々形成されている。

【０００４】フランジ付シャフト部材１、円筒状スリーブ部材４及び環状押さえ部材５との間には、微小隙間Ｒ１、Ｒ２、Ｒ３、Ｒ４及びＲ５が形成されている。微小隙間Ｒ１、Ｒ２、Ｒ３、Ｒ４は軸受隙間であり、微小隙間Ｒ５は潤滑油溜りとして機能するものである。これらすべての微小隙間には、潤滑油Ｆが充填されている。これらの微小隙間は、流体動圧軸受のサイズ、回転数及び潤滑油の粘性係数にもよるが、数μｍから数１００μｍ程度である。

【０００５】また、円筒状スリーブ部材４はステンレス鋼で作製し、且つフランジ付シャフト部材１はステンレス鋼よりも大きな線膨張係数を有する材料、例えば真ちゅうで製作されている。このように線膨張係数を考慮して軸受部材の材料を選定することによって、温度上昇に伴って軸受隙間の間隔が狭くなるようにしてある。軸受隙間の間隔は、温度によって自動的に調節されているのである。この軸受隙間の間隔の自動的な調節の効果によって、軸受剛性も自動的に調節されている。即ち高温域では、シャフト部材とスリーブ部材との間に形成された軸受隙間はその間隔が狭くなり、軸受剛性は増加する。この軸受剛性の増加は、潤滑油の粘性係数低下による軸受剛性の減少を或程度は補償する。

【０００６】図７に示す従来の液体動圧軸受は、円筒状スリーブ部材４とフランジ付シャフト部材１を後者の線膨張係数が前者のそれよりも大きくなるように選定することによって、軸受隙間の間隔を温度によって自動的に調節し、高温域での軸受剛性の低下を或程度は抑制するものである。しかしながら、一般に金属材料間の線膨張係数の差は高々$2\sim5\times10^{-5}$／℃程度であるから、温度により軸受隙間の間隔を自動的に調節できる幅が小さく、このため、従来の液体動圧軸受では軸受剛性を広い温度範囲にわたってほぼ一定に保持することは現実には極めて困難である。実現できたとしても、軸受を構成する材料の選定の幅が非常に狭く、様々な用途に適した液体動圧軸受をこのような方法では実現できないという問題がある。

【０００７】米国特許第５，５２４，９８５号公報には、金属製シャフト部材と金属製スリーブ部材と、これら２つ部材間に形成されたラジアル軸受隙間を含む微小隙間に充填された潤滑油とから構成された液体動圧軸受であって、ラジアル軸受隙間を形成する前記金属製スリ

ーブの内周面に合成樹脂のライニングを施した液体動圧軸受が開示されている。即ち、この液体動圧軸受は、合成樹脂の線膨張係数が金属よりも大きいことを利用して、高温域ではラジアル軸受隙間の間隔を狭め軸受剛性をほぼ一定に維持するようにしたものである。しかしながら、この液体動圧軸受も軸受を構成する材料の選定の幅が非常に狭く、様々な用途に適した液体動圧軸受をこのような方法では実現できないという問題がある。

【0008】これに対して、特開平10−112955号公報に開示された液体動圧軸受は、少なくともシャフト部材と、このシャフト部材を受けるスリーブ部材と、潤滑油とで構成されたものである。そして前記スリーブ部材は、その内周面を金属微粒子焼結物の如き多孔質材料で形成し、且つこの金属微粒子焼結物の多数の微小孔内にその焼結物よりも線膨張係数が大きな樹脂材料を充填させ、更にその内周面以外の全ての表面を潤滑油の漏出を防止するために水ガラスで封止してなるものである。また、シャフト部材には、線膨張係数がスリーブ部材の線膨張係数よりもやや大きな材料が採用されている。

【0009】この液体動圧軸受においては、潤滑油が常温以下である場合、その粘性係数は高くなるが、スリーブの内周面の微小孔に微小間隙を有するので、潤滑油はその微小孔を通じて圧力が高い部分から低い部分へ漏れて圧力の上がり過ぎを防ぎ、常温時以下における軸損の増大を軽減する。言わば、一種の含油軸受として機能させながら、スリーブの内周面に形成された多数の微小孔の微小間隙を温度によって自動的に調節しているものである。一方、潤滑油の温度が上昇すると、その粘性係数は低下するが、スリーブの内周面の微小孔の微小間隙が縮小し又は閉塞するので、潤滑油の圧力はその温度における潤滑油の粘性係数及び軸受隙間の間隔等のパラメータで決まる圧力に近づくか又はその圧力自体になり、温度上昇による軸受剛性の低下が防がれる。

【0010】特開平10−112955号公報に開示された液体動圧軸受は、その内周面を金属微粒子焼結物の如き多孔質材料で形成したスリーブ部材に充填された樹脂材料の熱膨張を利用して、多孔質材料の微小孔の微小間隙を温度によって自動的に調節し、軸受剛性を広い温度範囲にわたって可能な限り一定に保持しようとするものである。しかしながら、この方法によっても広い温度範囲にわたって軸受剛性をほぼ一定にした液体動圧軸受を実現することは現実には困難である。また、、特殊なスリーブ部材を用いたものであるから、その設計及び製作は容易ではなく、加工コストが高いという問題がある。

【0011】潤滑油を適切に選定することによって、液体動圧軸受の軸受剛性の温度依存性をある程度は緩和することができる。ところで、粘性係数が低い潤滑油は広い温度範囲にわたって粘性係数の変化が小さいので、液体動圧軸受の軸受剛性の温度依存性をある程度は緩和するという目的に適うものである。しかしながら、このような潤滑油は作り難いという問題がある。これに対して、粘性係数が高い潤滑油は作り易いが、広い温度範囲にわたって粘性係数が大きく変化する。従って軸受剛性は低温域では大きくなり過ぎ、また高温域では小さくなり過ぎる傾向がある。

【0012】

【発明が解決しようとする課題】本発明が解決しようとする課題は、シャフト部材と、このシャフト部材を受けるスリーブ部材と、これら2つの部材の間に形成された軸受隙間を含む微小隙間に充填された潤滑油とで構成された液体動圧軸受及びこれを具備したスピンドルモータにおいて、簡単な構成で、広い温度範囲にわたって、潤滑油の粘性係数による軸受剛性の変化を軸受隙間による軸受剛性の変化で補償し、軸受剛性をほぼ一定にすることである。

【0013】

【課題を解決するための手段】上記課題を解決するために、シャフト部材と、スリーブ部材と、これら2つの部材の間に形成された軸受隙間を含む微小隙間に充填された潤滑油とを含んで構成された液体動圧軸受において、前記シャフト部材の外面部を内面部の材料の線膨張係数よりも大きな材料で形成し、且つ前記スリーブ部材の内面部を外面部の材料の線膨張係数よりも大きな線膨張係数を有する材料で形成し、軸受隙間の間隔を温度によって自動的に調節するようにした。

【0014】また、フランジ付シャフト部材と、円筒状スリーブ部材と、環状押さえ部材と、これらの部材の間に形成された軸受隙間を含む微小隙間に充填された潤滑油とで構成された液体動圧軸受において、前記シャフト部材の外面部を内面部の材料の線膨張係数よりも大きな材料で形成し、前記スリーブ部材の内面部を外面部の材料の線膨張係数よりも大きな材料で形成し、更に前記環状押さえ部材の内面部を外面部の線膨張係数よりも大きな線膨張係数を有する材料で形成し、軸受隙間の間隔を温度によって自動的に調節するようにした。

【0015】更に、前記シャフト部材を外面部が内面部に外嵌されて形成された金属製シャフト部材とし、且つ前記スリーブ部材を内面部が外面部に内嵌されて形成された金属製スリーブ部材として、液体動圧軸受を構成した。

【0016】

【発明の実施の形態】本発明に係るスピンドルモータの一実施例は図1に示す如く、フランジ付シャフト部材1と段付円筒状スリーブ部材4とを含む液体動圧軸受、フランジ付シャフト部材1の端部に同軸にして固着されハードディスク等の回転体を保持するカップ状ハブ6、このカップ状ハブ6のスカート部の内周面に取り付けられたロータ磁石7、段付円筒状スリーブ部材4の外周面に

取り付けられてロータ磁石７と共働して回転力を発生させるステータコイル８、及びモータ基板９とから構成されている。

【００１７】図１のスピンドルモータに採用される液体動圧軸受の第１実施例は、潤滑油を除いた断面図である図２及び潤滑油を充填した部分断面図である図３に微小隙間を誇張して示す如く、フランジ付シャフト部材１と円筒状スリーブ部材４を含むものである。フランジ付シャフト部材１は円柱部材２と、この円柱部材２と一体に形成されたスラスト動圧用円盤部材３と、円柱部材２の下側に外嵌された円筒部材２ａとから構成された断面十字型部材である。ここで、シャフト外面部は円筒部材２ａであり、シャフト内面部は円筒部材２ａを除いたフランジ付シャフト部材１の残りの部分である。シャフト外面部はシャフト外面部の材料の線膨張係数よりも大きな線膨張係数を有する材料で構成されている。

【００１８】円筒状スリーブ部材４は、下段には底を有する小径の円筒部が、且つ上段には大気に開口した開口端を有する大径の円筒部が夫々形成され、更にその小径の円筒部に円筒部材４ａが内嵌された部材である。ここで、スリーブ内面部は円筒部材４ａであり、スリーブ外面部は円筒部材４ａを除いた円筒状スリーブ部材４の残りの部分である。スリーブ内面部はスリーブ外面部の材料の線膨張係数よりも大きな線膨張係数を有する材料で構成されている。

【００１９】円筒状スリーブ部材４の開口端には環状段部が形成されており、この環状段部には環状押さえ部材５が圧入され、これによって円筒状スリーブ部材４の開口端は塞がれている。ラジアル動圧発生溝Ｇ１は例えば部分溝又はヘリングボーン溝であって、円柱部材２の下側に外嵌された円筒部材２ａの外周面に形成されている。また、スラスト動圧発生溝Ｇ２は例えば図６に示すヘリングボーン溝であって、スラスト動圧用円盤部材３の上面と下面に夫々形成されている。ラジアル動圧発生溝Ｇ１は、円筒部材２ａでなく、スラスト動圧用円盤部材３の外周面に形成してもよい。

【００２０】フランジ付シャフト部材１、円筒状スリーブ部材４及び環状押さえ部材５との間に形成された微小隙間Ｒ１、Ｒ２、Ｒ３、Ｒ４及びＲ５には、潤滑オイルＦが充填されている。第１実施例において、ラジアル用軸受隙間は微小隙間Ｒ４であり、スラスト動圧用軸受隙間は微小隙間Ｒ１とＲ２である。円柱部材２の上側の外周面と環状押さえ部材５の内周面との間には断面が大気に開いた環状の微小なテーパー溝Ｓが形成されているが、これは毛細管現象と表面張力の作用を利用した潤滑油Ｆのキャピラリーシールである。

【００２１】第１実施例において、ラジアル動圧用軸受隙間Ｒ４に面するシャフト外面部を形成している部材とその内面部を構成している部材は、前者が後者よりも線膨張係数が大きい材料であり、且つラジアル動圧用軸受隙間Ｒ４に面するスリーブ内面部を形成している部材とその外面部を構成している部材は、前者が後者よりも線膨張係数が大きい材料である。

【００２２】このため、温度が上昇すると、フランジ付シャフト部材１、段付円筒状スリーブ部材４、環状押さえ部材５が膨張して微小隙間Ｒ１、Ｒ２、Ｒ３、Ｒ４及びＲ５の間隔が狭くなるが、特にラジアル動圧用軸受隙間Ｒ４の間隔の狭まり方が大きい。シャフト部材１においては線膨張係数の小さい部材で内側が規制されており、且つスリーブ部材４においては線膨張係数の小さい部材で外側が規制されているため、線膨張係数の大きいシャフト側の円筒部材２ａとスリーブ側の円筒部材４ａは軸受隙間の内側へより多く膨張するからである。逆に、温度が低下すると、フランジ付シャフト部材１、段付円筒状スリーブ部材４、環状押さえ部材５が収縮して微小隙間Ｒ１、Ｒ２、Ｒ３、Ｒ４及びＲ５の間隔が広くなるが、特にラジアル動圧用軸受隙間Ｒ４の間隔の広がり方が大きい。

【００２３】このようにして軸受隙間の間隔を従来装置よりも大きく変化させることができるようになり、本発明に係る液体動圧軸受においては温度により自動的に調節できる幅が広がった。従って、この温度による軸受隙間の間隔の自動的な調節の効果を利用して、軸受剛性をよりダイナミックに自動的に調節することができる。即ち高温域では、シャフト部材とスリーブ部材との間に形成されたラジアル動圧用軸受隙間はその間隔が狭くなり、軸受剛性は増加する。この軸受剛性の増加は、潤滑油の粘性係数低下による軸受剛性の減少を補償する大きさであり、従って高温域では所定の軸受剛性が保持される。一方、低温域では、シャフト部材とスリーブ部材との間に形成されたラジアル動圧用軸受隙間はその間隔が広くなり、軸受剛性は低下する。この軸受剛性の低下は、潤滑油の粘性係数上昇による軸受剛性の増加を補償する大きさであり、従って低温域でも所定の軸受剛性が保持される。即ち、広い温度範囲にわたって、潤滑油の粘性係数による軸受剛性の変化を軸受隙間による軸受剛性の変化で補償できるようになった。

【００２４】次に、液体動圧軸受の第２実施例は、潤滑油を除いた断面図である図４及び潤滑油を充填した部分断面図である図５に微小隙間を誇張して示す如く、その基本構成は第1実施例と同じである。違いは、温度による軸受隙間の自動的な間隔調節を実現する構成にある。即ちフランジ付シャフト部材１は円柱部材２と、この円柱部材２と別体に形成され円柱部材２の中間部に外嵌されたスラスト動圧用円盤部材３ａと、円柱部材２の下側に外嵌された円筒部材２ａとから構成された断面十字型部材である。スラスト動圧用円盤部材３ａと円筒部材２ａは一体に形成されている。ここで、シャフト外面部は円筒部材２ａとスラスト動圧用円盤部材３ａであり、シャフト内面部は円筒部材２ａとスラスト動圧用円盤部材

３ａを除いたフランジ付シャフト部材１の残りの部分である。シャフト外面部はシャフト外面部の材料の線膨張係数よりも大きな線膨張係数を有する材料で構成されている。

【００２５】液体動圧軸受の円筒状スリーブ部材４は、下段には底を有する小径の円筒部が、且つ上段には大気に開口した開口端を有する大径の円筒部が夫々形成され、更にその小径の円筒部と大径の円筒部とその間の段部には段付円筒部材４ａが内嵌された部材である。ここで、スリーブ内面部は円筒部材４ａであり、スリーブ外面部は円筒部材４ａを除いた円筒状スリーブ部材４の残りの部分である。スリーブ内面部はスリーブ外面部の材料の線膨張係数よりも大きな線膨張係数を有する材料で構成されている。

【００２６】円筒状スリーブ部材４の開口端には環状段部が形成されており、この環状段部には環状押さえ部材５が圧入され、これによって円筒状スリーブ部材４の開口端は塞がれている。環状押さえ部材５は微小隙間Ｒ１に面する内側に円盤部材５ａが内嵌されたものである。ここで、この円盤部材５ａの線膨張係数は、円盤部材５ａを除いた環状押さえ部材５の残りの部分の線膨張係数よりも大きい。

【００２７】第２実施例において、ラジアル動圧用軸受隙間Ｒ４に面するシャフト外面部を形成している部材とその内面部を構成している部材は前者が後者よりも線膨張係数が大きい材料であり、且つラジアル動圧用軸受隙間Ｒ４に面するスリーブ内面部を形成している部材とその外面部を構成している部材は前者が後者よりも線膨張係数が大きい材料である。また、スラスト動圧用軸受隙間Ｒ１に面するシャフト内面部を形成している部材と環状押さえ部材の内面部を形成している部材は、夫々の外面部を形成している部材と比較して、線膨張係数が大きい部材である。更に、スラスト動圧用軸受隙間Ｒ３に面するシャフト外面部を形成している部材とその内面部を構成している部材は前者が後者よりも線膨張係数が大きい材料であり、且つスラスト動圧用軸受隙間Ｒ３に面するスリーブ内面部を形成している部材とその外面部を構成している部材は前者が後者よりも線膨張係数が大きい材料である。

【００２８】このため、温度が上昇すると、フランジ付シャフト部材１、段付円筒状スリーブ部材４、環状押さえ部材５が膨張して微小隙間Ｒ１、Ｒ２、Ｒ３、Ｒ４及びＲ５の間隔が狭くなるが、特にスラスト動圧用軸受隙間Ｒ１とＲ２及びラジアル動圧用軸受隙間Ｒ４の間隔の狭まり方が大きい。逆に、温度が低下すると、フランジ付シャフト部材１、段付円筒状スリーブ部材４、環状押さえ部材５が収縮して微小隙間Ｒ１、Ｒ２、Ｒ３、Ｒ４及びＲ５の間隔が広くなるが、特にスラスト動圧用軸受隙間Ｒ１とＲ２及びラジアル動圧用軸受隙間Ｒ４の間隔の広がり方が大きい。

【００２９】このようにして軸受隙間の間隔を従来装置よりも大きく変化させることができるようになり、本発明に係る液体動圧軸受においては温度により自動的に調節できる幅が広がった。従って、この温度による軸受隙間の間隔の自動的な調節の効果を利用して、軸受剛性をよりダイナミックに自動的に調節することができる。即ち高温域では、シャフト部材とスリーブ部材との間に形成された軸受隙間はその間隔が狭くなり、軸受剛性は増加する。この軸受剛性の増加は、潤滑油の粘性係数低下による軸受剛性の減少を補償する大きさであり、従って高温域では所定の軸受剛性が保持される。一方、低温域では、シャフト部材とスリーブ部材との間に形成された軸受隙間はその間隔が広くなり、軸受剛性は低下する。この軸受剛性の低下は、粘性係数上昇による軸受剛性の増加を補償する大きさであり、従って低温域でも所定の軸受剛性が保持される。即ち、広い温度範囲にわたって、潤滑油の粘性係数による軸受剛性の変化を軸受隙間による軸受剛性の変化で補償できるようになった。

【００３０】なお、線膨張係数の大きい材料としてはリン青銅や真ちゅうなどの銅系金属、アルミニウム系金属、チタン系金属が適しており、また、線膨張係数の小さな材料としてはステンレスや純鉄などの鉄系金属やモリブデン系金属、タングステン系金属が適している。本発明に係る液体動圧軸受の設計においては、設計条件に基づいて、これらの材料の中から最適の組み合わせのものが選ばれる。また、軸受隙間は、使用最高温度においても隙間を保つように形成されていることは勿論である。

【００３１】

【発明の効果】本発明に係る液体動圧軸受は、シャフト部材の外面部を内面部の材料の線膨張係数よりも大きな材料で形成し、且つ前記スリーブ部材の内面部を外面部の材料の線膨張係数よりも大きな材料で形成し、軸受隙間の間隔の温度による変化幅を従来装置よりも大きくさせることができるようになり、温度により自動的に調節できる幅が広がった。従って、広い温度範囲にわたって、潤滑油の粘性係数による軸受剛性の変化を軸受隙間による軸受剛性の変化で補償できるようになり、軸受剛性をほぼ一定に保持することが可能になり、軸受性能の安定化を実現できた。

【００３２】また、その構成は製作しやすい比較的簡単なものであるから、液体動圧軸受の製造コストの上昇を抑えることができた。更に、広い温度範囲にわたって軸受隙間間隔の温度による自動的な調節が可能になったので、潤滑油の温度特性に対して自由度の高い設計が可能となり、小型薄型のスピンドルモータを容易に実現できるようになった。

【図面の簡単な説明】

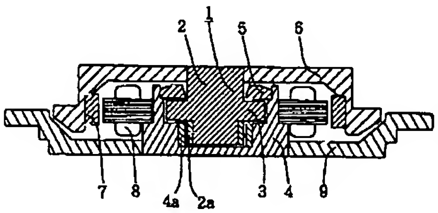
【図１】本発明に係る液体動圧軸受を備えたスピンドルモータの一実施例の断面図である。

【図２】本発明に係る液体動圧軸受の第１実施例の断面図である。
【図３】本発明に係る液体動圧軸受の第１実施例の部分断面図である。
【図４】本発明に係る液体動圧軸受の第２実施例の断面図である。
【図５】本発明に係る液体動圧軸受の第２実施例の部分断面図である。
【図６】スラスト動圧発生溝の一例を示す図である。
【図７】従来の液体動圧軸受の一例の部分断面図である。

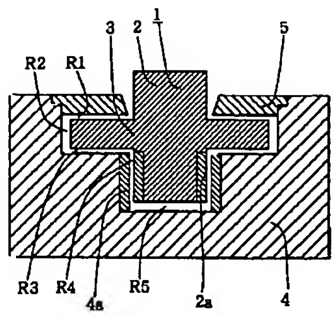
【符号の説明】

1　フランジ付シャフト部材
2　円柱部材
2ａ　シャフト外面部となる円筒部材
3　スラスト動圧用円盤部材
3ａ　シャフト外面部となるスラスト動圧用円盤部材
4　段付円筒状スリーブ部材
4ａ　スリーブ内面部となる円筒部材
4ｂ　スリーブ内面部となる段付円筒状スリーブ部材
5　環状押さえ部材
5ａ　環状押さえ部材の内面部を構成する円盤部材
6　カップ状ハブ
7　ロータ磁石
8　ステータコイル
9　モータ基板
Ｆ　潤滑オイル
Ｇ１　ラジアル動圧発生溝
Ｇ２　スラスト動圧発生溝
Ｒ１、Ｒ２、Ｒ３、Ｒ４、Ｒ５　微小隙間
Ｓ　キャピラリーシール

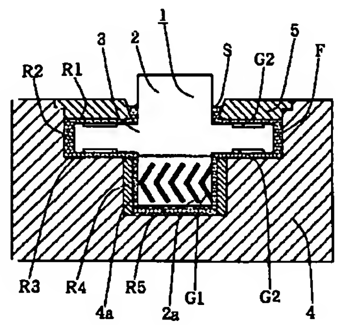
【図１】



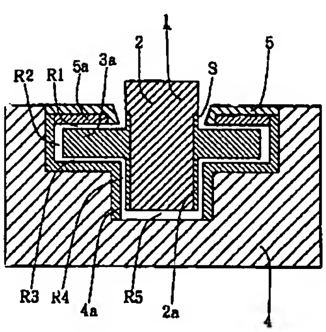
【図２】



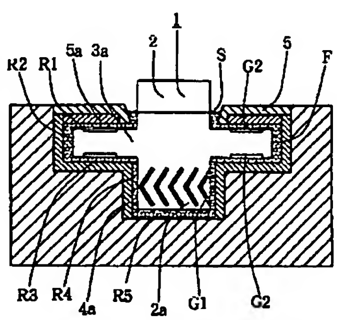
【図３】



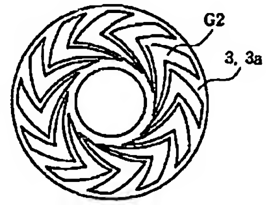
【図４】



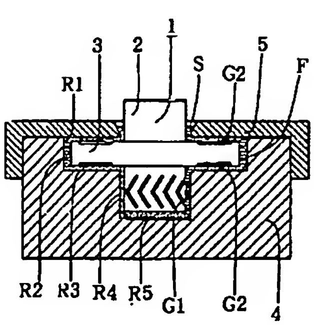
【図５】



【図６】



【図７】



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